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THE GROWTH OF THE STEAM-ENGINE

A History of the Growth of the Steam-Engine. By Robert H. Thurston, A.M., C.E., Professor of Mechanical Engineering, Stevens' Institute of Technology, &c. (London: C. Kegan Paul and Co., 1878.)

WE have before us a very striking instance of the value of a popular knowledge of mechanical philosophy.

The book is essentially divided into two parts. The first six chapters contain a history of the steam-engine as a machine; while Chapters vii. and viii. are devoted to the philosophy of the steam-engine, its history, and application.

As regards the first part we have but little to say. In two points this part of the book is distinctly commendable; the author gives ample reference to the numerous sources from which he has derived his information, and he has cast aside all national partiality. The literature of the history of the steam-engine is now so considerable that it can have been no small task to condense an abstract into something less than the limits of a small volume and at the same time make it interesting; and the success which has been attained must be largely attributed to the excellent illustrations. Much of the matter has doubtless come ready to the author's hand, requiring but little modification. In places the style of the author very closely resembles that of Mr. Smiles. The plan adopted is that of awarding unlimited praise to the various inventors instead of distinguishing between their various claims. Throughout this part of the book little or no attempt is made to explain the physical questions involved or to record the steps by which a knowledge of the physical properties of steam has been acquired.

Had, however, the first six chapters constituted the book, it must have been allowed to pass as a fairly full and very interesting account of the development and application of the mechanism of the steam-engine; much in the same style as the work of Dr. Lardner but in many respects much better and containing considerably more matter.

The history of the philosophy of the steam-engine contained in Chapter vii. might also be allowed to pass, although the assurance with which commendations are distributed to such men as Carnot, Joule, Mayer, Rankine, Regnault, and Thomson could only have been justified by evidence of the possession on the part of the author of a very unusual appreciation of the highest theory of his subject—an appreciation for which the earlier part of the work had in no way prepared us, and which is certainly not shown by the merit of the author's comments in this chapter. These comments, however, are of the most cursory kind, and although for the most part unintelligible, they did not prepare us for the disclosure of the last chapter, in which we have the author's own exposition of the philosophy of the steam engine and its application.

A suspicion that the author's physics are not what they should be began to dawn upon us when we came to the paragraph in which he describes the essentials of a good furnace, which suspicion was strengthened at the following sentence—"A pound of carbon has been found to be capable of liberating by its perfect combustion resulting in the formation of *carbonic oxide* 14,500 British thermal units—" but we still reserved our judgment, as carbonic oxide might be a misprint for carbonic acid. However, on turning over the page we find the following erroneous deduction:—

> "The laws of thermo-dynamics teach, as has been stated, that the proportion of the heat-energy contained in the steam or other working fluid which may be transformed into mechanical energy is a fraction, $\frac{H_1 - H_2}{H_1}$, of the total, in which H_1 and H_2 are the quantities of heat contained in the steam at the beginning and at the end of its operation, measuring from the absolute zero of heat motion. In perfect gases,
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> $$\frac{H_1 - H_2}{H_1} = \frac{\tau_1 - \tau_2}{\tau_1} = \frac{T_1 - T_2}{T_1 + 461{\cdot}2^\circ \text{ Fahr.}};$$
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> but in imperfect gases, and especially in vapours which, like steam, condense, or otherwise change their physical state, this equality does not exist, and $\frac{H_1 - H_2}{H_1} > \frac{\tau_1 - \tau_2}{\tau_1}$; and the fluid is more efficient than the perfect gas as a working substance in a heat-engine. In any case it is seen that the efficiency is greatest when the whole of the heat is received at the maximum and rejected at the minimum attainable temperatures."

This paragraph shows how completely the author has misapprehended the second law of thermo-dynamics. And this is not nearly all; the theory of the steam-engine is not so simple but that a slip of this sort might have been pardoned, but when we come to the author's application of the theory to the deduction of the economy of the "possible engine of the future," we have page after page of perfect nonsense, which not only shows that the author does not understand what he is writing about, but also shows that his erroneous views of, and imperfect acquaintance with, the theory of the steam-engine have led him into absurd errors from which the earlier inventors on whose work he has so boldly pronounced had emancipated themselves. How far this is the case will appear from the following quotations:—

> "Heat-engines may be divided, for present purposes, into three principal classes, according to their disposition of rejected heat:
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> "I. Those which restore all heat rejected from the working cylinder to the reservoir from which it was derived.
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> "II. Those which restore a part of the unutilised heat of the working fluid, discharging the remainder from the system and allowing it to be wasted.
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> "III. Those which waste all heat rejected from the working cylinder.
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> "No existing type of steam-engine belongs to the first of the classes specified. Some forms of air and gas-engines are theoretically assignable to that class, as, by means of some form of 'regenerator,' they store up rejected heat and restore it to the succeeding charge of working fluid as it enters the cylinder. . . .
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> "There are two forms of engines of Class I., in which—were it possible to fully avail ourselves of them—all this waste of energy may be avoided:
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> "Type A. The working fluid, if expanded from the temperature and pressure of the boiler or reservoir quite down to the absolute zero, would have all its heat-energy transformed into mechanical work, and there would be no waste. The efficiency would be perfect.

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"Type B. All heat rejected from the cylinder unutilised may be gathered up and restored to the boiler, there to serve as a basis upon which to pile a new stock of transformable heat-energy, instead of being, as now, rejected from the system entirely and lost. This done, there could be no loss, as all heat leaving the machine would be transmitted to exterior bodies as mechanical energy. Nothing being lost as heat, the efficiency of the engine would be unity and its economy a maximum.

"Forms of steam-engines may be conceived in which these methods (of saving heat now wasted) may be applied. Practically, however, it is evident, the first form of these two ideal engines can never be made successfully, since it would require to be made of such immense size that all the power derivable from it would be insufficient to move it."

An instance of the Type B is given. It is proposed to expand the steam in the cylinder until it is half liquefied, then separate the water from the steam and return them separately to the boiler, whereupon it is concluded.

"Under the conditions now assumed, it is evident that only that portion of the heat entering the engine which is surrendered by the condensation of steam doing work can be utilised. It is also evident that, in this form of engine, no heat can be lost; and, consequently, that the engine of Type B, which is operated as just indicated, will have yielded the exact equivalent of the net amount of heat expended upon it. *All heat rejected from the working cylinder, unutilised, being returned to the boiler*, there to form 'a basis on which to pile up a new stock of utilisable energy,' the engine is a 'perfect engine' in a broader sense than that adopted by Carnot. It is further evident that perfect efficiency is given for all ranges of temperature, and that what working fluid shall be adopted, and what temperatures shall be chosen, will be determined simply by practical conditions to be ascertained by experiment. . . .

"When this possible 'engine of the future' is likely to be introduced, if at all, can be scarcely even conjectured. It seems evident that its success is to be secured, if its introduction is ever attempted, by the adoption of high steam-pressures, of great piston-speeds, by care and skill in design, by the use of exceptionally excellent materials of construction, by great perfection of workmanship, and by intelligence in its management. There seems no tangible obstacle to its introduction." [1]

KINAHAN'S GEOLOGY OF IRELAND

Manual of the Geology of Ireland. By G. St. Kinahan, M.R.I.A., &c. (London: C. Kegan Paul and Co., 1878.)

THE appearance of another volume on Irish Geology, so soon after that of Prof. Hull, seems to show that the geologists of the Emerald Isle can be as active with their pens as with their hammers. Mr. Kinahan, indeed, has just claims to be heard when he treats of the rocks of his native country, for we suppose there is hardly any other living Irishman who has worked so long and so continuously among them. His volume, of course, coming before us as it does, cannot but challenge comparison with that of his director, Mr. Hull; and in truth it would almost appear as if this had been, consciously or not, in his mind. The two books, however, are on two very different plans. The general reader who wishes a pleasantly-written sketch of Irish geology, and of its relation to the scenery of the island, will find what he needs in Prof. Hull's chapters. Mr. Kinahan's work is more suited for professed geologists who propose to visit Ireland, and want to have some idea of the best districts to visit for their special purpose.

The volume is divided into five sections. In the first the author describes the sedimentary formations of Ireland, going over the country district by district, and pointing out in a useful, if somewhat prolix manner, the peculiarities of each. In the second he enters upon more speculative matter in an account of metamorphic and eruptive action as displayed among the Irish rocks. The third is devoted to the superficial accumulations, including the drift, the proofs of glaciation, changes of level, peat-bogs and prehistoric remains, and extinct mammalia. In the fourth section a brief description of the physical features is given from the writer's own point of view. The remaining division treats of the economically useful minerals of the country.

One cannot read Mr. Kinahan's pages without recognising his sturdy force of character. He takes up a position and holds it, one might almost think sometimes against his better judgment. It is satisfactory, however, to find him willing to yield sometimes, as, for instance, in his relinquishment of the absurd *yte* termination of rocks, though he takes care to inform us that while he yields to the entreaties of publishers and friends, he remains of the same opinion still. What a labour it must have been originally to change all his i-s into y-s! There are some other matters of orthography or even of grammar, which, when he feels himself to be in a compliant temper, he may take into his consideration. Why does he so constantly speak of "Cambrians" and "Silurians?" These are adjectives, and not nouns, and though in the field-slang of the Geological Survey, or of geologists generally they may be tolerated, they ought not to appear in any grave published work.

In the first section of the book it will probably occur to most readers that there is a want of breadth in the treatment of the subject. The local details are valuable as guides to the places and for the scattered facts they contain. But they lack that connecting thread which would have strung them all together and have carried the reader intelligently along, instead of leaving him, as he can hardly help feeling, struggling after the seven-leagued strides of Mr. Kinahan as he hops from district to district. Brief summaries for the separate regions, and a general connected summary of the whole for the system or formation, would have given the reader the key to the details. And as regards these details we fear they are often too vague to be of as much service to the field-geologist as he would wish them to be. The kind of detail he needs is supplied by the valuable "Explanations of the Geological Survey of Ireland." Mr. Kinahan often, indeed, refers to these "Explanations," but he would have given his volume a more practically useful character had he inserted in the account of each district a reference to the particular explanation in which a fuller description may be found. Such references, for the purposes of the student and the geologist who wants to study the matter on the ground, cannot be too precise and frequent. As it is, Mr. Kinahan's chapters on the rocks and struc-

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[1] "The idea first suggested itself to the mind of the writer in 1858–59, when at Brown University, and while designing a peculiar form of 'drop cut-off engine,' which was intended to work with exceptional economy. The plans then conceived have gradually assumed a different shape, but still embody the essential principles here outlined. Mr. C. E. Emery, in 1868, proposed a similar plan."

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